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Environmental Security Issues in the Black Sea Region

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Environmental Restoration Division

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Table of Contents

Executive Summary Ex-1
1. Background 1
  1.1. General Description 1
  1.2. Multinational Agreements 2
  1.3. Recent Environmental and Oceanographic Activities 3
  1.4. Existing Data Bases and Data Management Systems 7
2. Environmental Impacts 8
  2.1. Nutrients and Eutrophication 9
  2.2. Chemical and Microbiological Pollution 10
    2.2.1. Pesticides and Herbicides 10
    2.2.2. Heavy Metals and Radionuclides 10
    2.2.3. Microbial Pathogens 11
  2.3. Oil Spills 11
  2.4. Dumping and Toxic Waste 12
  2.5. Military Activities 12
  2.6. Marine Intruder Species 12
  2.7. Changes in Hydrological Balance 12
  2.8. Overfishing 13
3. Environmental Issues From Caspian Sea Oil and Gas Development 13
4. Future Needs 15
  4.1. Monitoring and Remediation Programs 15
  4.2. Stakeholder Involvement 16
5. References 17
6. Acronyms and Abbreviations 18

List of Figures

Figure 1-1. Map of the Black Sea and the coastal countries.

Figure 2-1. The key contributing factors to the environmental degradation of the Black Sea. A dead zone covers 90% of the Black Sea below 200 meters. This is due to organic material falling to the bottom of the sea and depleting the oxygen as it decomposes.

Figure 2-2. Proportion of nitrogen and phosphorous loads into the Black Sea from all sources, including atmospheric deposition, and industrial, municipal, and agricultural sources.

Figure 2-3. Nitrogen and phosphorous discharges from non-atmospheric sources, including major rivers, and direct discharges from each of the Black Sea countries.

Figure 2-4. Wastewater discharges from each of the Black Sea countries and the major rivers, as measured by biological oxygen demand (BOD).

Figure 2-5. Exisitng and planned oil pipelines from the Caspian Sea. Routes for the planned U.S.- and Russian-backed Main Export Pipelines (MEP) are shown.

List of Tables

Table 1-1. The catchment area for the Black Sea.

Table 1-2. Recent environmental/oceanographic programs in the Black Sea.

Table 2-1. Pollutant loads for the Mediterranean Sea and the Black Sea.

Table 2-2. Oil Pollution in the Black Sea.

Executive Summary

The Black Sea is of global interest on several levels. First, it has the worst environmental degradation of all of the world's oceans. The environmental situation has become so severe that it is affecting the health, well being, and standard of living of the people living in the immediate area. Second, it is bordered by six countries, Russia, Turkey, Ukraine, Georgia, Bulgaria, and Romania, most of which have unstable or collapsed economies. Although international agreements, strategic plans, and national environmental programs are in place, these severe economic problems have slowed environmental monitoring and remediation significantly. Third, the Black Sea and the surrounding countries are critical to the distribution of the Caspian Sea basin oil and gas supplies to western countries.

The environmental crisis is a direct effect of both natural and anthropogenic causes, which have forced dramatic changes in the Black Sea's ecosystem and resources. The Black Sea is extremely vulnerable to anthropogenic pollution. It is very deep (more than 2 km), and the only outlet is through the narrow, shallow (100 m deep) Bosphorous Strait. It's surface area is five times smaller than its catchment basin. The primary causes for the deterioration include the enormous increase in the nutrient and pollutant load from three major rivers, the Danube, Dniester and Dnieper, and from pollution sources along the coast and on the open sea. As a result, the Black Sea has become the largest anoxic water basin in the world. Fishery biodiversity and yields have declined dramatically in recent years. Water-borne cholera and hepatitis epidemics have broken out periodically in the northern coastal areas. Tourism has severely decreased.

In addition, there are emerging developments, which will further degrade the Black Sea environment. The flow of oil and gas from the Caspian Sea will increase significantly next year. New pipelines, which will terminate in (1) Novorossiysk, Russia and (2) Supsa, Georgia, are under construction. Consequently, oil tanker traffic through the Bosphorous Straits will increase significantly. The environmental situation in the Black Sea region is important to western countries, because it can affect the multi-national cooperation among the Black Sea and Caspian Sea countries, and impact the international community with strategic energy interests in the region.

Steps need to be taken to deal with the continuing environmental deterioration of the Black Sea. These include additional environmental monitoring, environmental modeling, control of ongoing pollution, oil spill prevention and response, catchment basin pollution control, coastal zone pollution control, and remediation of existing pollution. These steps will depend on the cooperation of the Black Sea countries, and their ability to overcome the massive economic, political, and ethnic problems facing the region.

1. Background

1.1. General Description

The map in Figure 1-1 shows the Black Sea region and the six coastal countries: Turkey, Russia, Ukraine, Georgia, Bulgaria, and Romania. The Black Sea has a surface area of 423,000 km^2, one-fifth the surface area of the Mediterranean, a total volume of 547,000 km^3, and a maximum depth of 2245 m (Zaitsev and Mamaev, 1997).

The north-western continental shelf, less than 200 m deep, and occupying 25% of the Sea area receives discharges of three of Europe's largest rivers: Danube, Dnieper and Don, and also the Dniester and Kuban Rivers. Table 1-1 shows the catchment area, about 2 million km^2, and the length, and runoff for these rivers: Danube (contributing about 209 km^3 of water a year—which is more than the entire fresh water input to the North Sea); Dnieper, delivering yearly 44 km^3 of water; and the Don, with the contribution of 21.9 km^3 yearly (GEF, 1996). The Don and the Kuban rivers empty into the Sea of Azov. Therefore, the shallow biologically productive layer of the Black Sea receives water from a vast drainage basin over five times its own area covering huge industrial and agricultural areas of 22 countries. These include the 6 coastal countries and 16 other Eastern and Central European countries: Albania, Austria, Bosnia, Croatia, Czech Republic, Germany, Hungary, Italy, Macedonia, Moldova, Poland, Slovakia, Slovenia, Switzerland, and Yugoslavia. About 162 million people live in the Black Sea catchment basin, including 80 million people living in the Danube River basin. The Black Sea coasts are important tourist areas, with about 40 million visitors during the summer, compared to 10 million inhabitants.

The Black Sea has only a small outlet, which is through the shallow and narrow Bosphorous Strait, 31 km long, 0.7 to 3.5 km wide, and 30–100 m deep, which connects to the Mediterranean through the Sea of Marmara and the Dardanelles. In the north the Black Sea is connected to the shallow Sea of Azov by the Kerch Strait, which has an area of 39,000 km^2, an average depth of 8 m, with a maximum depth of 12 m.

The inflow of salty water from the Mediterranean is outweighed by the outflow of fresh water from the Black Sea. This results in a stratification of the water column with fresher water (salinity 17–19 parts per trillion [ppt]) at the surface and denser water (salinity about 22 ppt) at depth. This permanent halocline is a distinguishing feature of the Black Sea. The difference in density and the lack of vertical currents prevents mixing and subsequent oxygen penetration from the surface to the bottom. Over the years, organic matter has been sinking and decomposing, and below a depth of 150–200 m the Black Sea is permanently anoxic. This means that 90% of its water mass is anoxic, making it the largest volume of anoxic water on our planet. Since the dissolved oxygen is not sufficient, organic matter degradation uses oxygen bound in nitrates, and especially in sulfates, which results in the production of hydrogen sulfide. Hydrogen sulfide has contaminated 90% of the water volume of the Black Sea, allowing the existence of only anaerobic bacteria.

The surface water temperature varies from 0 degrees C in the NW coast in the winter to 25 degrees C in the west in the summer. The deep water at 1,000 ft is constant at 9 degrees C all year. The input from the large rivers on the NW shelf are transported by gyres throughout the Black Sea. During the last 30 years, the damming of the Danube and other rivers has decreased the freshwater input to the Black Sea by up to one fifth, and the decrease in sediment load has resulted in erosion along the Romanian coast. Heavy pollution, increased agricultural runoff, and limited mixing result in oxygen depletion in the coastal areas during the summers.

In 1995, the European Environmental Agency performed assessments of the occurrence and relative importance of the common problems among the European Seas, including the Mediterranean, Black, Caspian, White, Barents, Norwegian, Baltic, North Seas, and the north Atlantic Ocean. The Black Sea was rated as having the highest concerns in five out of seven categories, the worst of any of the seas (Stanners and Boudreau, 1995):

- Overexploitation of resources - highest concern.
- Lack of effective catchment management - highest concern.
- Coastal zone pollution - highest concern.
- Eutrophication - highest concern.
- Introduction of non-indigenous species - highest concern.
- Offshore activities - small or localized problem.
- Conflict of uses of coastal zone - small or localized problem.

1.2. Multinational Agreements

By the late 1980s, the Black Sea was already in a critical condition due to industrial growth, neglect, and the lack of general public environmental awareness. Up until 1992, the Black Sea was unprotected by any common policy or legal regime. In 1992, the Bucharest Convention ratified in 1994, was the first significant multi-national agreement for clean up. This was followed by the high-level Odessa Ministerial Declaration in 1993, and the Black Sea Environmental Program (BSEP). The BSEP then drafted the Black Sea Strategic Action Plan (BSSAP) in 1996 and initiated its implementation. Unfortunately, recent economic problems have significantly slowed the progress toward mitigation. The individual agreements are discussed below.

1992 Bucharest Convention on the Protection of the Black Sea Against Pollution

The 1992 Bucharest Convention on the Protection of the Black Sea Against Pollution initiated long-term cooperation on cleaning up the Black Sea, and was ratified by representatives of the Black Sea countries in 1994. The Convention calls on all Parties to take all necessary measures to prevent pollution from numerous sources. It also establishes a Central Commission and permanent Secretariat, and calls for regional and national contingency plans for pollution emergencies. The Global Environment Facility (GEF) assisted the countries in drawing up action plans for implementation. It includes three protocols and one draft protocol:

- Protection of the Black Sea against Pollution From Land-Based Sources.
- Cooperation in Combating Pollution of the Black Sea Marine Environment by Oil and Other Harmful Substances in Emergency Situations.
- Protection of the Black Sea Marine Environment Against Pollution by Dumping.

- Cooperation in Controlling Transboundary Movement of Hazardous Wastes and Combating Illegal Traffic Thereof (draft).

1993 Odessa Ministerial Declaration

All of the Black Sea countries signed the Declaration at ministerial levels. This Declaration reflects many of the same commitments as the Bucharest Convention. However, it goes further by delineating specific actions and milestones, including the establishment of Regional Activity Centers among the Black Sea countries. These Centers were then later incorporated into the BSEP, as described below.

1995 Black Sea Regional Energy Centre (BSREC)

The six countries of the Black Sea together with Albania, Armenia, Azerbaijan, Moldova, and the European Union (EU), jointly established the BSREC in 1995 in Sofia, Bulgaria. The BSREC aims to reinforce the cooperation between the EU and the Black Sea region countries in the energy sector, in order to strengthen political and economic stability, and to promote peace and greater prosperity in the region.

The main objectives of the Centre are:

- Promotion of energy policy development and application, and energy market reform with reference to the EU Energy Charter.
- Promotion of investment, funding and joint ventures in the energy sector.
- Provide easy access to all EU institutions.
- Creation of a home for Black Sea regional initiatives.
- Provide coordination services for the EU Programs.

One of the five themes of the Centre is the consequences to the environment from the exploration, production and transportation of the energy resources of the Black Sea region. The internet address is: http://www.bsrec.bg.

1996 Black Sea Strategic Action Plan (BSSAP)

To implement the Bucharest Convention, the 1996 Black Sea Strategic Action Plan was signed by ministers and officials of the six Black Sea countries as part of the BSEP. The 88-point plan sets out short- and long-term goals for the future, from monitoring and treatment of the polluted water to schemes for raising public awareness. The document highlights different sources of pollution, particular problem areas, pollution regulation and monitoring, management and protection of living resources, and sustainable development. Each country was required to submit a National Black Sea Strategic Action Plan by October 1997. The BSSAP committed the six Black Sea coastal countries to actions, with objectives and milestones, for restoring the Black Sea.

1.3. Recent Environmental and Oceanographic Activities

There have been several Black Sea programs sponsored by international organizations, however most of them terminated before or during 1998. Under the Soviet system a large number of scientists worked on water body management problems, but the links between their work and official decision making were not strong (Dimento, 1998). Table 1-2 summarizes the programs, which are described below.

Black Sea Environmental Program (BSEP) 1993–1998

The BSEP has been the most important environmental activity in the Black Sea, and it was established after the ministerial declaration of cooperation was signed in Odessa in 1993 (GEF, 1996). A Program Coordination Unit (PCU) was established in Istanbul to coordinate the work on a regional level, and communicate with international organizations and multilateral and bilateral donors. The PCU was replaced by a Project Implementation Unit, co-managed by the United Nations Development Program (UNDP) in spring 1998. The Program was funded as a pilot program from 1993 to 1997 by the Global Environment Facility (GEF), and the European Union's (EU's) programs and with bilateral funds from Canada, Netherlands, Switzerland, Japan, Austria, and France. The primary objective has been to implement policy for the assessment, control, and prevention of pollution, and to preserve biodiversity. The internet address is:

http://www.dominet.com.tr/blacksea/.

One of the purposes of the BSEP PCU is to coordinate seven Advisory Groups and Activity Centers which were established by the BSSAP:

- Environmental Safety Aspects of Shipping: Coordinated by the Emergency Response Activity Center in Varna, Bulgaria.
- Pollution Monitoring and Assessment: Coordinated by the Special Monitoring Programs Activity Center in Odessa, Ukraine.
- Control of Pollution from Land-Based Sources: Coordinated by the Routine Pollution Monitoring Center in Istanbul, Turkey.
- Development of Common Methodologies for Integrated Coastal Zone Management: Coordinated by the Activity Center in Krasnodar (Novorossiysk), Russia.
- Conservation of Biological Diversity: Coordinated by the Biodiversity Center in Batumi, Georgia.
- Fisheries and Other Living Marine Resources: Coordinated by the Fisheries Activity Center in Constanta, Romania.
- Information and Data Exchange: Coordinated by the Commission Secretariat.

The major accomplishment was the preparation of the Transboundary Diagnostic Analysis (TDA), which formed the basis of the BSSAP in 1996. The TDA identified the major sources of environmental degradation:

- Eutrophication and overuse of marine natural resources.
- Poor coastal management.
- Industrial hot spots.
- Poor port reception facilities.
- Inadequate sewage treatment systems.

The BSEP includes anti-pollution actions, sustainable economic development, environmental impact assessments, and quotas on fishing. Environmental protection plans include building water treatment plants for sewage in all coastal cities, and the introduction of a "polluter pays" principle.

The BSEP appears to be foundering because of a lack of financial support from the participating Black Sea countries, which are struggling to keep up with payments required by the BSSAP. Funding from the GEF ended in 1997, and smaller funding sources remained for the rest of 1998. The long-term future of the project is uncertain. Many of the countries are facing severe economic problems, which limits the amount of money available for environmental projects. The EU provided start-up costs, but the long-term clean up is the responsibility of the individual and collective Black Sea countries.

NATO Science and Committee on the Challenges of Modern Society (CCMS) Programs 1993–1998

The NATO Science for Stability Program sponsored two multi-institutional projects coordinated through the Middle East Technical University in Erdemil, Turkey. The two projects dealt with "Ecosystem Modeling as a Management Tool for the Black Sea" (TU-BLACK SEA) 1993–1997, and "Wave Climatology of the Turkish Coast: Measurements-Analysis - Modeling" (TU-WAVES) 1993–1998. The TU-BLACK SEA Project had three major objectives: modeling, capacity building, and establishing a common database management system (DBMS) for environmental and oceanographic data. This DBMS database was established at the Marine Hydrophysical Institute at Sevastopol, Ukraine. It includes 30 years of environmental and oceanographic data, and is expected to serve as a baseline for future research activities and management. The goal of the TU-WAVES Project was to improve knowledge on wind and waves over the entire Black Sea, and to generate a reliable data base through the operation of a network of wave measurements and analysis in real time.

The Special Working Group 12 (SWG/12) was another NATO initiative which promotes co-operation among NATO and Partnership for Peace navies to comply with national and international maritime environmental protection regulations and to foster cooperative efforts for achieving environmentally sound ships and support facilities. The SWG/12 has assisted the Romanian and Bulgarian navies, and is helping to develop an oil-spill response contingency plan.

The NATO CCMS sponsored a pilot project devoted to a Review of Ongoing Black Sea Projects for the Planning of Future Activities. This project was terminated in 1997. This CCMS project was led by Turkey and the USA, with scientists from Russia, Turkey, USA, Bulgaria, Ukraine, Georgia, and Romania, and produced a "Black Sea Observation and Forecasting System (BSOFS) Science Plan" (NATO/CCMS, 1997), which provided recommendations for the implementation of a long-term operational ocean observation and forecasting program for the Black Sea. The BSOFS is intended to be a permanent operational system that will be developed and continually improved. The strategy is to develop the BSOFS over a ten-year period, in three phases. The first two phases (six years) involve:

- Development of coupled models capable of assimilating physical, chemical, and biological variables.
- Construction of the observational network of multiple platforms and multivariable sensors.

The third phase involves the demonstration of the operational feasibility of the system with the ultimate goal of interfacing to users for forecasting purposes.

Other NATO initiatives were supported by Linkage Grants and Advance Research Workshops from the Environmental Security Program.

EROS 2000 Program 1994–1997

The EROS 2000 (European River Ocean System) Program of the EU ran 1994–1997, and focused on the Northwestern Black Sea. Its major objective was the development of an integrated approach to address the problems of eutrophication, contaminants, particle transfer, sedimentation and biogas production. A related task is the utilization of interdisciplinary models for the coupled ocean river systems for the prediction of the coastal ecosystem's response to natural and man made changes in land use and hydraulic management.

IOC Cooperative Marine Science (CoMSBlack) Program 1991–???

The purpose of the Intergovernmental Oceanographic Commission (IOC) Cooperative Marine Science Program (CoMSBlack) which began in 1991, was to establish a scientific basis for the effective and integrated management of the Black Sea, including environmental preservation, protection and optimum utilization. The IOC assembly established the program to co-ordinate marine programs at an intergovernmental level, along with other international organizations. The major objectives are:

- Assess natural and induced environmental changes using historical data.
- Determine fluxes of water, sediment, carbon, nutrients, heavy metals, hydrocarbons from rivers, atmosphere, straits and bottom sediments within the basin.
- Provide a quantitative understanding of the transport and cycling of these materials.

A series of basin, sub-basin, and regional-scale oceanographic surveys were carried out between 1991 and 1993. Typically, 300 hydrographic and 100 biochemical stations were visited by 4–5 ships on a regional basis. The data collected were used in developing a new physical and biogeochemical model of the Black Sea (IOC, 1996). In 1996, the IOC established two pilot programs. One was called STOP, Step Towards Observation and Prediction Systems, which was designed to develop and improve regional capabilities on operational oceanography. The other pilot program assesses the spatial and temporal variability of sediment flux and its effect on ecosystems in the Black Sea.

Danube River Basin and Danube Delta Programs 1991–1998

The Danube River Basin program was established in 1991 by 11 major Danube countries: Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Romania, Slovakia, Slovenia, and Ukraine. It was supported by the EU and GEF, and it included water-quality monitoring, marine accident warning systems, data collection and assessment, environmental management of the catchment area, and a 1995–2005 Strategic Action Plan for regional actions on the high priority environmental problems in the Basin. The Danube Delta Project complements other GEF-sponsored projects. This project focuses on the both the Romanian and the Ukrainian delta ecosystems.

Azov Sea Project 1993–1995

The Azov Sea Project, 1993–95, was supported by Delft Hydraulics under supervision of The Netherlands Ministry of Transport, Public Works, and Water Management. The major objectives were to develop models and management systems for environmental policy analysis and implementation.

IAEA Research Program 1994–1996

The IAEA coordinated a 1994–1996 research program on "The Application of Tracer Techniques in the Study of Processes and Pollution in the Black Sea." The major objectives were to assess the radionuclide inventory, evaluate future trends in radioactive pollution, and to apply tracer techniques to study oceanographic processes and pollutant transport. The interest was in radionuclides associated with the Chernobyl accident and from local nuclear facilities.

Other Programs

Other international organizations such as the Food and Agricultural Organization, World Health Organization, and the International Maritime Organization also support smaller specific programs in ocean research.

1.4. Existing Data Bases and Data Management Systems

At the present time, there is no central data center for storing regional data on a long-term basis. There are numerous data sets existing in various institutions, and some of these are digitized. Collection of real-time marine data has not yet been organized or implemented in the Black Sea region. There are a few databases, which include:

Black Sea Database - Marine Hydrophysical Institute (MHI) Sevastopol, Ukraine

This database contains physical and chemical data from the MHI archives. Biological data is not included.

Black Sea Database - Russian Hydrometeorological Service (Obninsk)

This database contains meteorological, physical, and chemical data from the FSU marine institutes.

EROS 2000 Database

This database contains a small number of data sets obtained by the EROS 2000 project.

Black Sea Geographic Information System (GIS) - BSEP

This database, generated as part of the BSEP, covers the large-scale region of the Black Sea. It consists of 550 maps arranged in seven blocks representing different aspects of the ecosystem.

Black Sea Information System (BSIS) - BSEP

This database, developed as part of the BSEP, consists of the following directories:

- Addresses and profiles of participating institutions in the Black Sea.
- Major marine environmental data sets.
- Scientists working on the Black Sea.
- International research and projects in the Black Sea.
- Cruise summary reports.
- Bibliography.

Black Sea Database - NATO TU - MHI, Sevastopol, Ukraine

This is the NATO TU project database management system (DBMS), and currently includes data from over 26,000 oceanographic stations. The main features are:

- All main physical, chemical, and biological variables for the Black Sea Basin.
- Data spans 1963–1995.
- Data from all main regional and international sources.
- Software is included for sorting and combining data.
- Includes about 10–30% of all measurements in the Black Sea.

2. Environmental Impacts

Figure 2.1 graphically depicts some of the key contributing factors to the environmental degradation of the Black Sea (Murphy, 1997):

- Eutrophication and algae blooms in the NW Sea.
- Chemical and microbiological pollution
- Untreated sewage along the western coast.
- Oil tanker traffic in the Bosphorous.
- The future increase in the oil flow through the Sea.
- Intrusion of the jellyfish, Mnemiopsis Leidyl.
- Pollution of the sturgeon spawning habitat.
- Overfishing.

These contributing factors, and several others, including the dead zone of hydrogen sulfide below 200 m, are discussed in detail below. Table 2-1 shows the comparative pollutant loads for the Mediterranean Sea and the Black Sea for selected pollutants. The loadings are generally comparable, even though the area and volume of the Mediterranean are six times the area and volume of the Black Sea (Palshin, 1998). The specific pollutants are discussed below.

2.1. Nutrients and Eutrophication

The main ecological problem in the Black Sea is the huge influx of nutrients and pollutants, coupled with the poor ventilation of the deep waters. In the past 25 years, an enormous increase in the nutrient load to the Black Sea has been observed, specifically, a two- to three-fold increase in nitrates, and a seven-fold increase in phosphates from 1970–1991. This is caused by the widespread use of phosphate detergents and intensification of agriculture which uses fertilizers and causes nutrient-leaching from the soil. Figure 2-2 shows nitrogen and phosphorous input into the Black Sea from all sources, including atmospheric deposition and discharges from rivers, including industrial, agriculture, and domestic wastewater (Stanners and Boudreau, 1995). Atmospheric deposition contributes only a minor amount of nitrogen and phosphorous, 19%, and 8%, respectively. Agriculture and domestic wastewater contributed the largest shares. Figure 2-3 shows that the Danube is the single largest source, introducing about 60,000 tons of total phosphorus/year (66%). The share of inorganic nitrogen in the Danube discharge makes about 340,000 tons/year (53%), which is more than double the load from the Rhine. In addition to this, some coastal settlements, of which Romania, Russia, and Turkey have the highest numbers, discharge their sewage and industrial wastes directly to the sea (GEF, 1996). Even though nutrient loads may be reduced in the future, the sediment-bound nutrients will be released only very slowly, and eutrophication will gradually diminish over time.

As a result, the major part of the Black Sea, particularly, its north-western (NW) shelf has become critically eutrophic. About 25% of the area of the Black Sea is occupied by the NW shelf, which is less than 200 m deep. In the past, this area was the most productive and the most biologically diverse part of the Black Sea. The immediate consequence of increased nutrient supply has been the intensification of phytoplankton blooms of which the long term effects have been devastating.

The results can be summed up as follows (Stanners and Boudreau, 1995).

- Phytoplankton blooms have grown from 52 g to 1 kg per m^3, and the blooming area in the NW region has increased 10–30 times since 1950–60.
- The euphotic zone, i.e., the surface layer where the light level is sufficient for net biological primary production, has gradually become shallower. The decrease went from 50–60 m in the early 1960s to about 35 m today, and even less than 10 m in coastal waters.
- The enormous increase in organic matter falling to the shelf floor from blooming and decaying organisms has resulted in widespread hypoxia (almost 95% of the north-western Black Sea shelf). Only 13% of the total water in the Black Sea contains oxygen. There is debate over the relative anthropogenic contribution to the hydrogen sulfide problem. Several sources have quoted claims that the hydrogen sulfide condition has existed due to natural input from the rivers, even before man populated the Black Sea region (Dimento, 1998; Ascherson, 1995)
- The profound alteration of the marine ecosystem, primarily as a result of eutrophication, has contributed to the demise of formerly rich Black Sea fisheries. There are 180 species of fish in the Black Sea. In fact, of 26 high-value species in the 1960s, only 6 remain in significant commercially harvested quantities. The decrease in shell-fish population on the NW shelf has fallen from 10 to 3 million tons. Bottom fish like flounder and crabs have

practically disappeared. Dolphins have decreased from 1–2 million to 450,000. Giant sturgeon are endangered, and turbot, mussels, and mullets are seriously depleted.

2.2. Chemical and Microbiological Pollution

The Danube river is the largest single source of chemical and biological pollution for the Black Sea. It is clear that other rivers of the Black Sea Basin, running on the former Soviet Union territory have also been seriously contaminated with industrial and mining wastes. Besides river discharge of contaminants, many coastal industries discharge unknown quantities directly to the sea with little or no treatment.

2.2.1. Pesticides and Herbicides

There are generally no validated data on pesticides from the Black Sea, although total organochlorine pesticides have been measured at 5 nanograms/mL in the open sea (Stanners and Boudreau, 1995). At the same time, water measurements conducted in 1981–82 in the Danube delta revealed total insecticide and lindane concentrations of about 1,000 times those observed in north-western Mediterranean coastal waters. Recent levels of insecticides from the Kerch Straits between the Azov and Black Seas are two orders of magnitude higher than in the Mediterranean. Water from the Dnieper, the second largest river of the basin, is used to irrigate large areas of rice paddies where insecticides and herbicides are applied in considerable quantities.

2.2.2. Heavy Metals and Radionuclides

Concentrations of heavy metal and radionuclides are highly variable, and are generally higher in coastal waters, and lower in the open sea. Heavy metal concentrations generally are close to normal on the open sea, on average. However, elevated levels occur in “hot spots” and in the Danube River delta. The Danube discharges annually about (Mee, 1992):

- 1,000 tons of chromium.
- 900 tons of copper.
- 60 tons of mercury.
- 6,000 tons of zinc.
- 280 tons of cadmium.
- 4,500 tons of lead.

Compared to the open sea, high coastal values of cadmium in Romania (1.6 versus 0.05 micrograms/mL), mercury in Bulgaria (2.6 versus 0.1 micrograms/mL), and copper in Bulgaria (83 versus 0.5 micrograms/mL) have been found (Stanners and Boudreau, 1995).

The BSEP studies show that, since the Chernobyl accident, the concentration of artificial radionuclides in various compartments of the Black Sea has increased. Since the Chernobyl accident, the content of Cs-137 has doubled, and Sr-90 has increased by 20%. Average concentration of Cs-137 in the top 200 m layer of the Black Sea is 30 BQ/m^3, which is a factor of 3 increase following Chernobyl. Concentrations of some radionuclides are ten times higher than the Mediterranean. However, radiation levels in fish (mainly from Cs-137, Cs-134, and Sr-90) are within acceptable levels for human intake (UMEP, 1997). Very little information has been gathered on alpha-emitting radionuclides, and more complete dose assessments are needed.

2.2.3. Microbial Pathogens

In the coastal region 10 million people discharge 570 million cubic meters of sewage each year into the Black Sea, either directly or via rivers. Figure 2-4 shows the breakdown of the wastewater discharges from all sources, as measured by biological oxygen demand (BOD), which is a measure of the amount of biochemically degradable organic matter in a water body. As with most other pollutants, the Danube River is the largest single source (75%). Among the coastal countries, domestic sources in Turkey and the industrial sources in the Ukraine generate the most wastewater (Stanners and Boudreau, 1995). Alarming increases of pathogenic microorganisms are observed in the sea water, bottom sediments and many marine organisms. The most frequently observed pathogens are E. coli, Staphylococcus, and Salmonella. Average E. coli concentrations in the sea water near Odessa have increased 500 times since the 1940s, and have reached 100,000–1,000,000 cells per liter (Palshin, 1998). Perhaps the clearest evidence that a problem exists are the reports of limited outbreaks of water borne cholera in the summer of 1970 (in the northern Black Sea estuarian areas and the Sea of Azov) and again in 1991 (on the Romanian and Ukrainian sides of the Danube delta). Cases of Hepatitis A have increased, especially in the Crimea and Nikolayev regions. Unsanitary conditions have led to the temporary closures of an increasing number of Ukrainian and Russian beaches during the holiday seasons.

2.3. Oil Spills

Areas around the Black Sea are severely polluted with oil, particularly near ports. Sevastopol Bay is the most polluted, with an average concentration of 5 mg/L, about 100 times higher than the FSU water standard (0.05 mg/L). The average open sea concentration has been measured at 0.1 mg/L. About 110 thousand tons of oil are introduced into the Black Sea each year, and about 48% comes from the Danube. The rest comes from land-based sources, due to inadequate waste treatment and poor handling of oil and oil products. Table 2-2 shows the breakdown by source and by country (BSEP, 1996). Of course, illegal oil dumping, which could be very high, is not included in the estimates. More recent data from coastal waters off Odessa reveal an average concentration of total petroleum hydrocarbons of 0.06 mg/L (range 0.005-0.18 mg/L). Oil pollution along shipping lanes is especially heavy (typically 0.3 mg/L). Inadequate port reception facilities in the Black Sea and deballasting activities, particularly in the Western region; and offshore oil and gas exploration (and limited production underway in Romania and Bulgaria) obviously require that a proper assessment of oil pollution be urgently undertaken, particularly, of the more toxic polycyclic aromatic hydrocarbon fraction.

Because of the extreme vulnerability of the Black Sea to oil pollution, regional and national oil spill response contingency plans are critically important. In 1995 the BSEP conducted an assessment of the status of existing contingency plans, “Emergency Response and Contingency Planning in the Black Sea Region: Current Status and Strategies for Improvement” (BSEP, 1996). It found that all of the Black Sea countries have some guidance recognizing the local port or shipping authorities as the responsible parties in an oil spill. However, only Turkey has special legislation covering the responsibilities of governmental institutions and other organizations in the event of an oil spill. All plans have to be based on IMO guidelines, however, the assessment found that IMO guidelines were not consistently followed. Furthermore, the ships, aircraft, and other hardware designated for oil spill response are generally old, and in need of repair or replacement. In 1997, a Black Sea oil spill response contingency plan was prepared with assistance from the IMO, and that plan has been distributed to each Black Sea country through the Emergency Response Center in Varna, Bulgaria.

2.4. Dumping and Toxic Waste

There are 16 official dump sites in the western Black Sea. The negative impact of this activity on benthic biota has not been characterized or quantified. Since many of those areas are discharge sites for rivers (as well as industrial and domestic effluents) dumping may be a mechanism for bypassing the natural "estuarian filter" for contaminants and introducing toxic materials to the open sea.

2.5. Military Activities

Considerable oil pollution has been observed in the area of Sevastopol, Kerch, Nikolayev, and Odessa from the Ukranian navy’s operations. In Sevastopol Bay pollutant concentrations range from 100 to 2,000 times the admissible levels. Several years ago, data was released on the burial of yperite and lewisite. The quantities and impacts of toxic wastes and chemical weapons buried under the Sea still need to be measured and assessed (Palshin, 1998).

2.6. Marine Intruder Species

Special ecological conditions of the Black Sea, i.e., high primary productivity and low salinity, allow opportunistic predator species, brought in the ballast water of ships to find an ecological niche in which to flourish. The first documented case was that one of the snail Rapana, introduced from Japan in late 1940s. It is widely held as responsible for the demise of commercially harvested oyster populations and a general decrease of biodiversity.

There have been other cases of species introduction, but the worst impact was from the ctenophore Mnemiopsis, a predatory comb jelly from the Atlantic, which led to the explosive increase in organic matter falling to the shelf floor from blooming and decaying organisms since 1988. Together with the jelly fish, Aurelia aurita, it feeds on other zooplankton, including fish larvae, and appears to have no natural predators. As a result, many fish species were pushed to extinction. The fish catch decreased from 850,000 tons in the 1980s to 250,000 tons in 1991 (Kinzer, 1998).

2.7. Changes in Hydrological Balance

Construction of dams on major rivers for irrigation and power generation purposes has resulted in a substantial net decrease in the runoff to the NW part of the Black Sea and to the Sea of Azov. This causes a reduction in the freshwater and sediment inflow into these areas, resulting in coastal erosion and salinity changes. This may lead to an alteration in the exchange through the Bosphorous and thus, to negative consequences even in the distant Eastern Mediterranean.

2.8. Overfishing

One of the most spectacular cases of overfishing is that of the Turkish coast fisheries, which were the most significant fisheries in 1985. The total capture of anchovy and mackerel had increased to 338,000 tons in 1984 and supplied 80% of the national demand for fish in Turkey. Within the three year period 1987–89 the fisheries collapsed to under 15,000 tons. Various factors were involved in this matter, one of which was overfishing. Due to the large incentives to fishermen to improve their gear, even the 1–3 year class stock has been captured, which contributed to the dramatic decrease in stock quantity (Palshin, 1998).

3. Environmental Issues From Caspian Sea Oil and Gas Development

Estimates of the Caspian Basin oil reserves vary widely, and range from 200 to 300 billion barrels of oil or its equivalent in natural gas, which is worth about $5 trillion at average 1990s prices. These estimates are comparable to the 260 billion barrels proven for Saudi Arabia reserves, even though the proven Caspian Sea reserves are currently 15–30 billion barrels. However, the production costs for Caspian Sea oil are much higher. The production cost to bring Caspian Sea oil to market is about $10 a barrel, whereas it is only $4 for the oil from Saudi Arabia.

Today oil is being transported to the West through the Black Sea to the Mediterranean Sea in two ways (Fig. 2-4, Viviano, 1998a):

- By an existing Russian pipeline from the shores of the Caspian Sea at Baku, Azerbaijan to Novrossiysk, Russia on the Black Sea.
- By rail from Baku, Azerbaijan to Supsa, Georgia on the Black Sea.

The oil is being transported by tanker through the Bosphorous Strait to the Mediterranean Sea for distribution to the West. In 1997, oil tankers, which carry about 3 billion barrels of oil (Viviano, 1998b), accounted for 7,000 out of 50,000 vessels through the Bosphorous Strait.

Today, the USA and Russia, along with other countries, are involved in competing projects to bring the huge finds of Caspian oil to the Mediterranean. The projects include overland pipelines, underwater pipelines, tankers for oil transport, and the construction of a number of oil terminals. Western oil companies, who are involved in the region, include Chevron, Unocal, AMOCO, Mobil, Exxon, Shell, BP, and Phillips. It has been estimated that by 2010, oil companies will have invested as much as $50 billion in the Caspian oil fields, not including the billions spent to develop gas fields and build pipelines (Kinzer, 1998).

Construction of new terminals is in progress for:

- An estimated 250 million barrels/year of oil coming through a new Russian pipeline to Novorossiysk.
- A new $600 million U.S. government-backed pipeline from Baku, Azerbaijan to Supsa, Georgia carrying 300 million barrels /year. This pipeline is scheduled to begin pumping oil April 1, 1999.

The combined annual capacity of the two new pipelines is estimated at 550 million barrels of oil, which will increase to 7 billion barrels by 2005. A third larger pipeline already under construction, the $2 billion Main Export Pipeline proposed by Russia, will run from Atyrau in the Tengiz oil fields in Kazakhstan to Novorossiysk. This will carry as much as 3.5 billion barrels/year by 2005.

It is obvious that any major oil spill in the closed ecosystem of the Black Sea will have catastrophic consequences. The oil spill danger is especially acute for the Bosphorous Strait. In 1994 a tanker accident dumped 1 million barrels of oil on the shores of Istanbul, and in August 1998, a supertanker with 7 million barrels ran aground. The Bosphorous is already so crowded that the Turkish government has announced plans to limit ship traffic.

To minimize new spills in the Bosphorous Strait, the Turkish government, supported by the U.S. government, is pushing for a future 1,080-mile Main Export Pipeline, which will connect from Tbilisi, Georgia to Ceyhan, Turkey on the Mediterranean in order to avoid the Black Sea. On October 29, 1998, the presidents of Turkey, Azerbaijan, Georgia, Kazakstan, and Uzbekistan signed an accord committing their governments to the conduit. This pipeline could cost $4+ billion, and, because of its enormous cost, which is double the cost of alternative routes, the Azerbaijan International Operating Consortium (AIOC), a cartel of 12 oil companies, may not build the Tbilisi-Ceyhan connection. In addition, this option has its own set of problems, because Ceyhan is near earthquake faults. Ceyhan experienced significant damage from a severe earthquake on June 29, 1998. Turkey has warned that it will boycott Caspian oil purchases, and will take steps to prevent shipments elsewhere through the Bosphorous, if its Ceyhan proposal is turned down (Viviano, 1998c). The U.S. government is advising Turkey to provide subsidies to the AIOC to build the Baku-Ceyhan pipeline, but no commitments have been made to date. In another development, officials in Bulgaria, Romania and Ukraine have announced that they want to receive Caspian oil at ports on the western shore of the Sea to send west on barges or through existing pipelines (Kinzer, 1998).

Compounding the environmental problems in the Black Sea is the unexplained rapid rise in the water level of the Caspian Sea. The water level has risen seven ft in 18 years, and it is estimated that it will rise another seven to 10 ft. Because of this, the coast has been receding by over 30 ft per year since the late 1970s. Flooding has contaminated surface and groundwaters with toxic substances 10–100 times acceptable limits in some places, and threatens large numbers of oil operations, towns, industries, railroads, farms, and grasslands, affecting over 400,000 people in Azerbaijan and Kazakstan.

This same Black Sea/Caspian Sea area is currently undergoing great civil unrest. Six conflicts and rebellions are underway in the Caspian area: civil war between ethnic Georgians and ethnic Abkhazians in the Georgia province of Abkhazia; rebellion in Russia's north Ossetia province; unrest in Chechnya, despite a 1996 cease-fire; rebellion in Russia's Dagestan province; the Kurdish uprising in eastern Turkey, and conflict between Azerbaijan and Armenia in the Nagorno-Karabakh region. The pipelines carrying oil and gas must transit these politically unstable regions.

The pipeline route through Iran to the Persian Gulf, at half the cost of the Baku-Ceyhan pipeline, appears to be the option with the lowest construction cost and environmental risks, but the U.S. government is adamantly opposed to this alternative.

4. Future Needs

4.1. Monitoring and Remediation Programs

Environmental management of the Black Sea remains an enormous challenge. The Black Sea TDA claims that the environment can still be restored and protected. The 1996 BSSAP concluded that the recent monitoring showed slight improvements in some localized areas, and that the Mneniopsis was in slight decline. In addition, Dimento concludes that there is comparatively modest movement toward international water cooperation in the Sea. He also endorses that the greatest political barrier to cooperation is the emergence of nationalism and religious fundamentalism in Turkey and the FSU states (Dimento, 1998).

Monitoring Activities

As discussed in Sections 2 and 3, existing environmental/oceanographic activities in the Black Sea have been of limited duration and scope, and most of those activities have terminated. New monitoring programs that utilize real-time or near real-time physical, chemical and biological observations designed to validate conceptual physical biogeochemical modeling activities are needed. Such models are useful for assessing basin-wide environmental contamination and resulting ecosystem impacts based on limited observations and measurements.

Specific needs for additional measurements and assessments include:

- The quantities and impacts of releases from the toxic waste dumps, which discharge and leach into the Black Sea.
- The distribution and impacts of oil pollution, particularly, of the more toxic polycyclic aromatic hydrocarbon fraction.
- The quantities and impact of alpha-emitting radionuclides.
- The quantities and impacts of leaks from chemical weapons buried under the Sea.

Remediation Activities

Since the catchment area is five times the surface area, the Black Sea receives contaminants which may originate hundreds and thousands of kilometers away from the sea. Therefore, effective catchment area management and pollution control actions require international cooperation. Since the Odessa Declaration, some progress has been made in cleaning up the Black Sea. Countries have adopted some low and non-waste generating technologies. Although sewage is still often untreated before direct discharge into rivers or the Sea, some new systems have been constructed and existing systems renovated. Dumping radioactive materials into the Black Sea has apparently stopped. Attempts to develop plans for emergency response plans, monitoring systems, and coastal zone management are underway. Nevertheless, although there have been remediation activities in individual countries, there has not been a coordinated effort, specifically to:

- Reduce harmful substances passing into the Sea.
- Reduce transboundary movement of hazardous wastes.

- Regulate and reduce pollution from ships.

At the present time, there is not a multi-national Black Sea oil spill response program, which is being effectively implemented. The adoption and implementation of a response plan is essential before the huge increases in Caspian Sea oil start flowing through the Black Sea. However, this issue has received much attention recently, and there is renewed activity on the part of the U.S. government to facilitate the integration of multi-national resources towards developing an effective oil spill prevention and response capability.

These measurements and modeling activities, as well as remediation activities, could be coordinated through a central Black Sea Environmental Center, which would have the responsibility for serving and maintaining a web site which contains a central data repository along with data analysis software “tools” for interpreting, graphing and picturing the experimental environmental and oceanographic data. The results of the modeling would also be accessible there. However, in order to implement such a system, the existing communication capabilities must be significantly upgraded to allow rapid transfer of large data sets among the scientists of the Black Sea countries. This web site would also include a portion that is dedicated to decision makers and public stakeholder use.

4.2. Stakeholder Involvement

The 1992 Bucharest Convention encouraged public participation, including Non-Governmental Organizations (NGOs). In addition, the EU has supported public awareness and environmental education activities. As a result, numerous new NGOs have been formed in the region.

The general levels of environmental awareness and education among the population of the Black Sea countries are low compared to those of western countries. Compounding this problem has been the lack of public participation, absence of transparent decision making, lack of a modern regulatory approach, lack of technical assistance, and lack of adequate funding. This is one of the roots of environmental and public health problems in these countries, especially the Ukraine. Currently, the population of Ukraine does not consider the Black Sea pollution as a national problem. The Chernobyl catastrophe was a starting point for increasing public interest in the environment. Of course, the radioactive waste contamination is only a part of the general environmental safety problems, and in most cases, the chemical contamination is more important, even for the Ukraine (Palshin, 1998).

Improving both the environmental knowledge and culture of the population in this field is necessary. Raising the knowledge and awareness level of the environment can reduce the level of pollution of land, water, and air, especially in the countryside. In the case of agricultural activity, the countermeasures are not expensive, but must be conducted on a large-scale basis. Television, film, popular brochures, etc. will attract public interest in environmental problems, and such changes in public opinion can be the basis for parliamentary legislation and governmental action.

The economic and political problems in this region, including recent currency devaluation, ethnic conflicts, priorities of social programs, and weaknesses of the environmental ministries, are significant obstacles to adequate water management in the Black Sea. However, these obstacles are not insurmountable.

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6. Acronyms and Abbreviations

AIOC	Azerbaijan International Operating Consortium
BQ	Becquerel (radioactivity measurement)
BSEP	Black Sea Environmental Program
BSOFS	Black Sea Observation and Forecasting System
BSREC	Black Sea Regional Energy Centre
BSSAP	Black Sea Strategic Action Plan
C	Celsius (temperature)
CCMS	NATO Committee on Challenges of the Modern Society
DBMS	NATO Data Base Management System
EROS	European River - Ocean System Program of the EU
EU	European Union
FSU	Former Soviet Union
ft	Foot, feet
g	Gram
GEF	Global Environmental Facility; co-managed by the UNEP and the World Bank
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
km	Kilometer
L	Liter
m	Meter
mg	Milligram
MHI	Marine Hydrophysical Institute in Sevastopol, Ukraine
mL	Milliliter
NATO	North Atlantic Treaty Organization
NGO	Non-Governmental Organization
NW	North west or North-western
PCU	Program Coordination Unit of the BSEP
ppt	Parts per trillion
SFS	NATO Program of Science for Stability
STOP	Step Towards Observation and Prediction
STOPS	IOC Program of Step Towards Observation and Prediction Systems
SWG/12	NATO Special Working Group 12
TDA	Transboundary Diagnostic Analysis
TU	Middle East Technical University in Erdemil, Turkey
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program

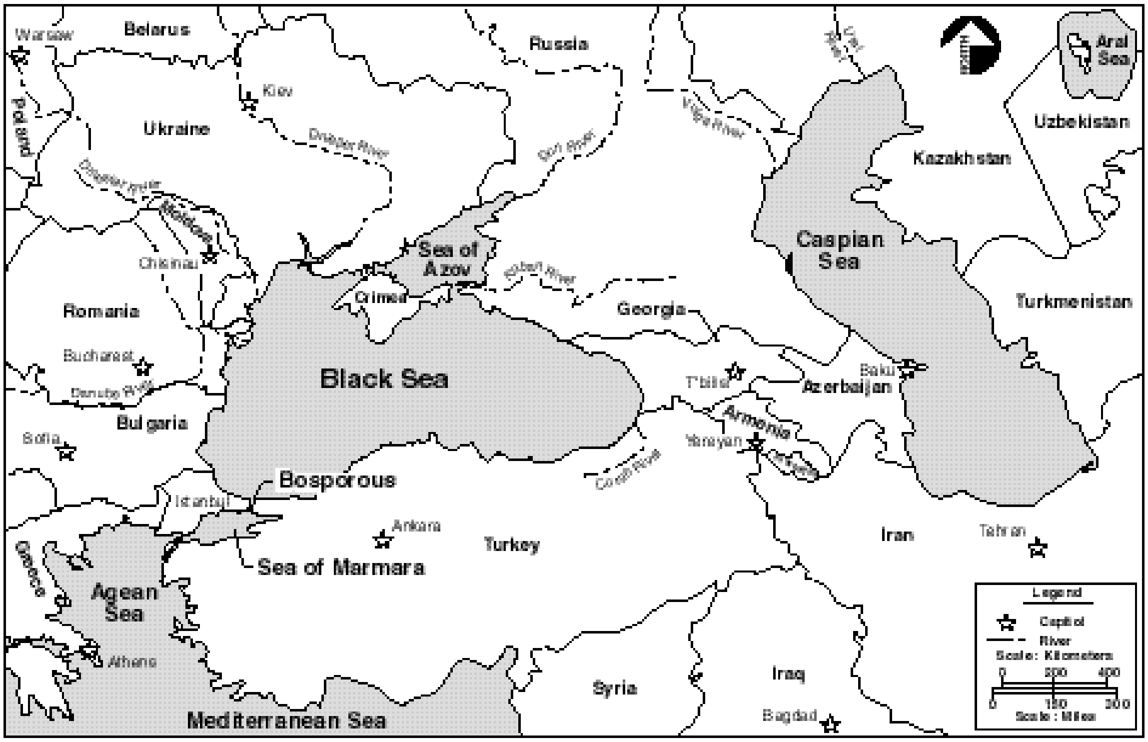

Figure 1-1. Map of the Black Sea and the coastal countries.

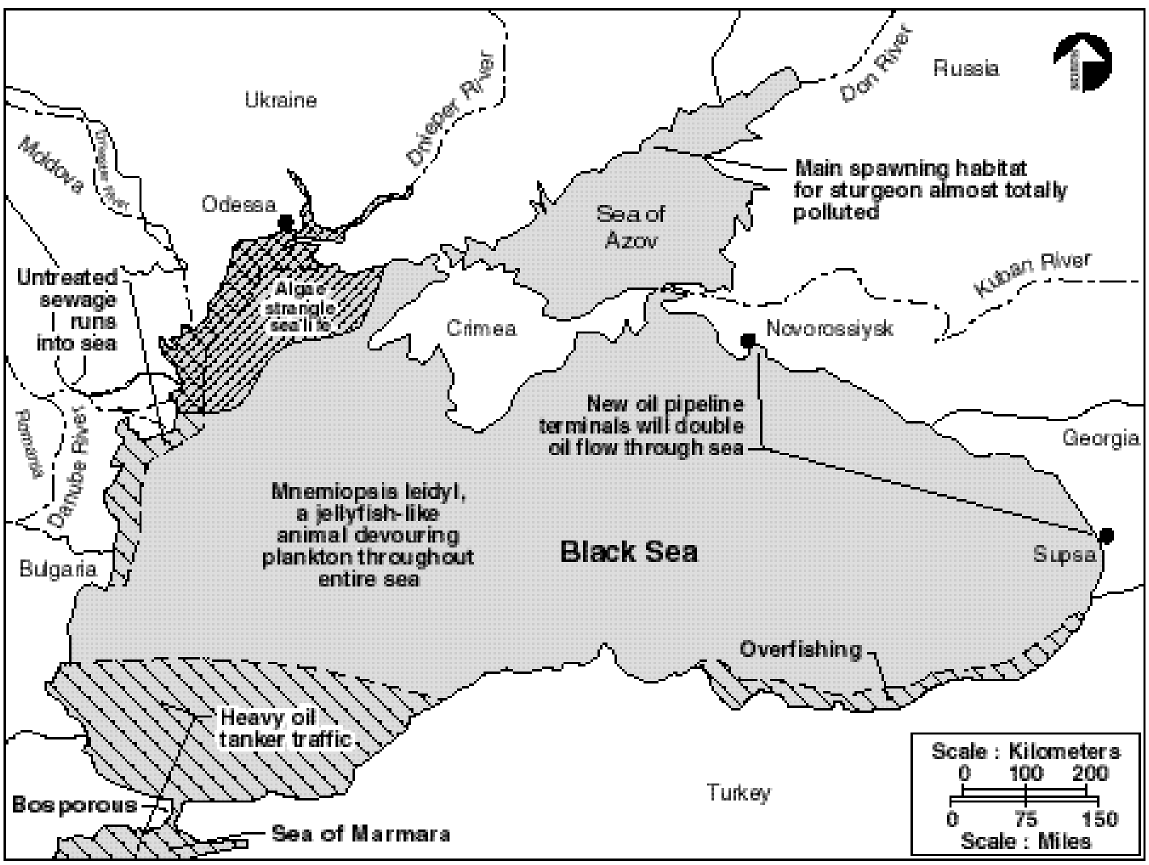

Figure 2-1. The key contributing factors to the environmental degradation of the Black Sea. A dead zone covers 90% of the Black Sea below 200 meters. This is due to organic material falling to the bottom of the sea and depleting the oxygen as it decomposes.

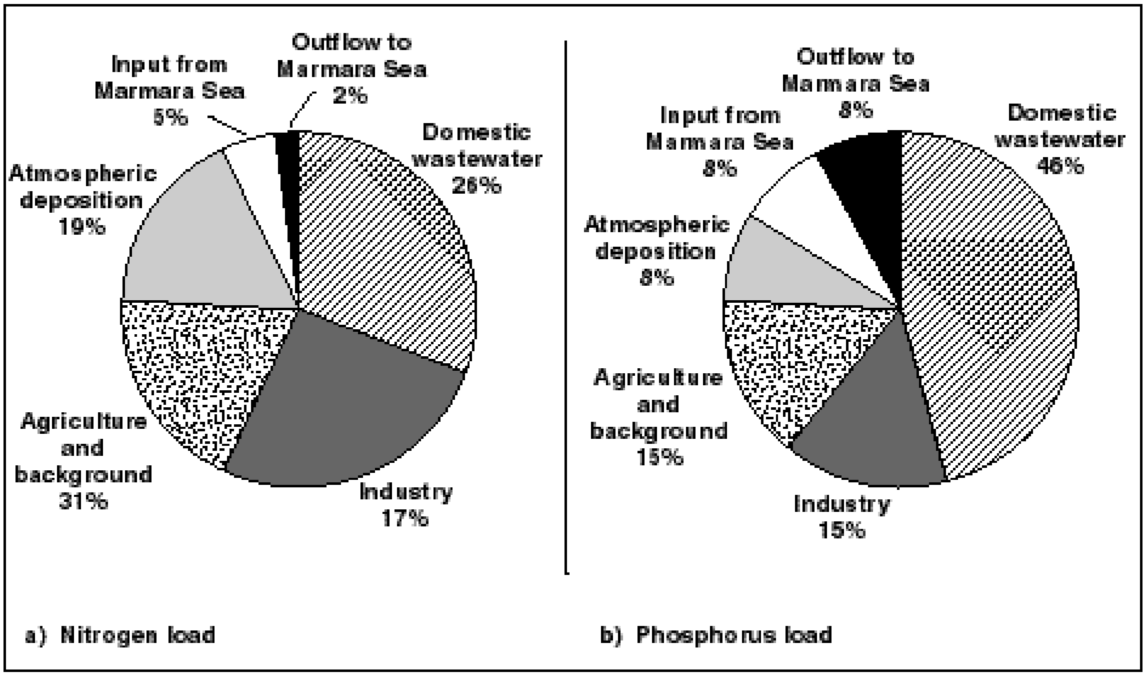

Figure 2-2. Proportion of nitrogen and phosphorous loads into the Black Sea from all sources, including atmospheric deposition, and industrial, municipal, and agricultural sources.

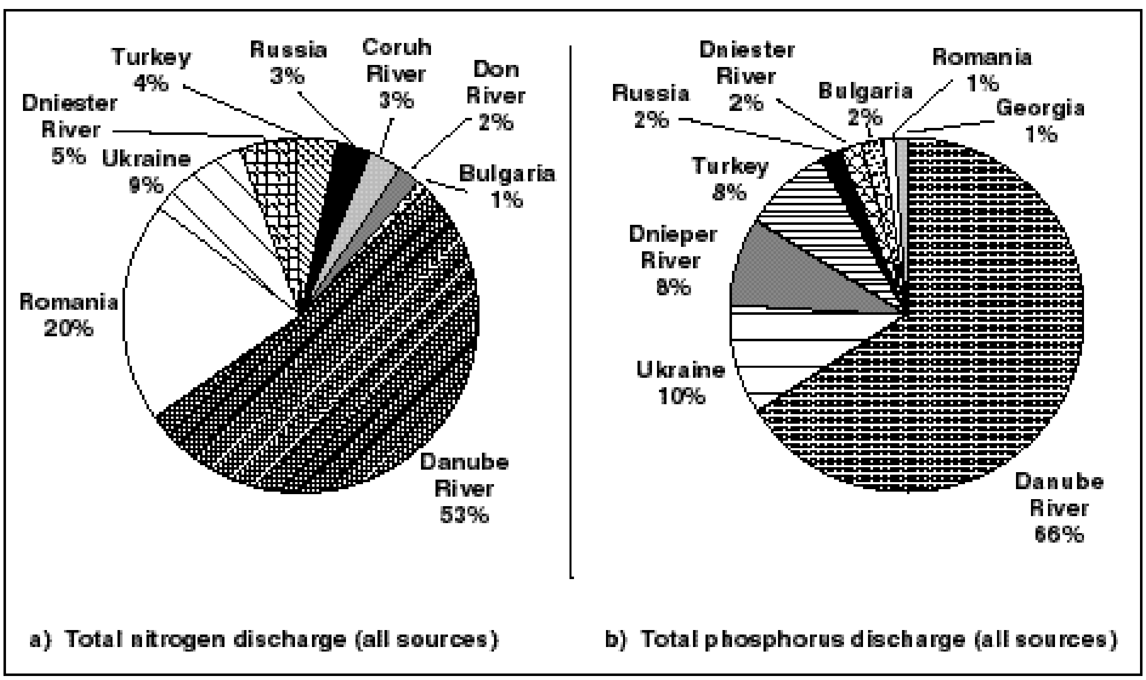

Figure 2-3. Nitrogen and phosphorous discharges from non-atmospheric sources, including major rivers, and direct discharges from each of the Black Sea countries.

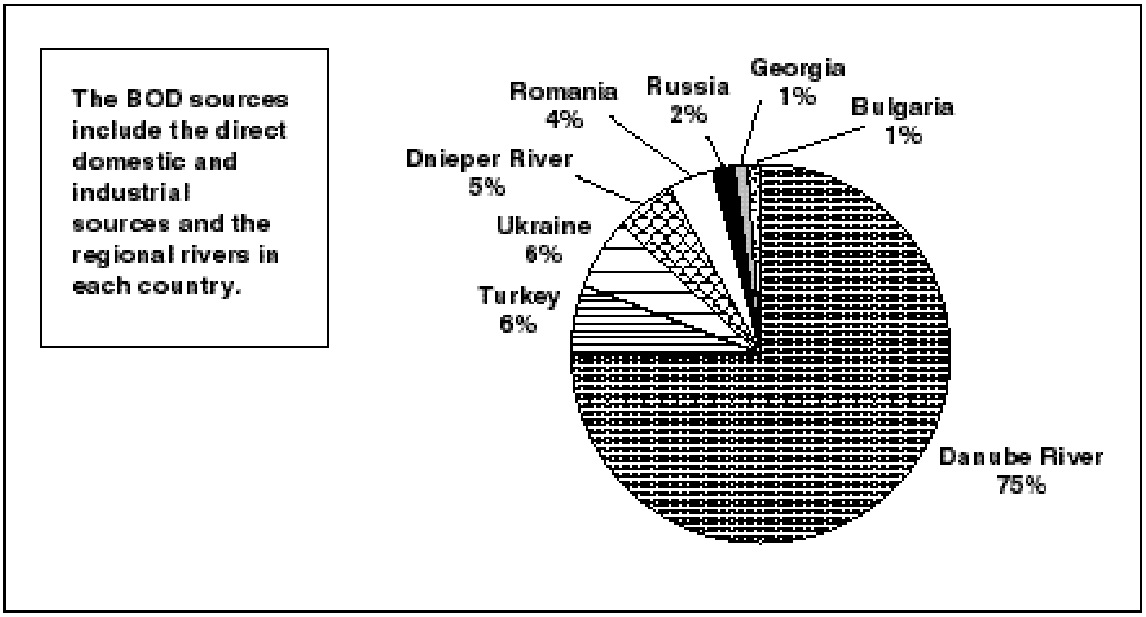

Figure 2-4. Wastewater discharges from each of the Black Sea countries and the major rivers as measured by biological oxygen demand (BOD).

Figure 2-5. Exisitng and planned oil pipelines from the Caspian Sea. Routes for the planned U.S.- and Russian-backed Main Export Pipelines (MEP) are shown.

Table 1-1. Catchment area for the Black Sea[a].

River	Catchment Area (1,000 km²)	Length (km)	Average Runoff (km³/yr)
Danube	817	2,857	209.3
Dnieper	504	2,200	44.2
Don	422	1,870	21.9
Dniester	72	1,350	6.6
Kuban	58	870	9.3
Total	1,873		291.3

[a] Surface area = 423,000 km^2.

Table 1-2. Recent Black Sea environmental programs.

Sponsor(s)	Program	Dates
IOC	CoMSBlack	1991–
EU/GEF	Danube River	1992–1999
GEF	BSEP I & II	1993–1998
EU	EROS-21	1993–2001
NATO	TU	1993–1997
NATO	Waves	1993–1998
Netherlands	Azov Sea	1993–1995
IAEA	Tracer Applications	1994–1996
GEF	Danube Delta	1994–1998
IOC	STOPS	1996– 1998
IOC	Sediment Flux	1996–2000

Table 2-1. Estimated pollutant loads on the Black Sea and the Mediterranean Sea (1,000 tons/year).

Pollutant	Mediterranean	Black Sea
Nitrogen	800	570
Phosphorous	320	140
Mercury	0.1	0.082
Oil	750	206
Zinc	21	12
Chromium	2.4	1.5
Lead	3.8	4.5
Detergent	60	48
Phenols	12	2.2
Area	2,500,000 km^2	423,000 km^2
Volume	3,700,000 km^3	534,000 km^3

Table 2-2. Oil Pollution in the Black Sea (ton/yr).

Country	Total	Domestic	Industrial	Land-based	Local Rivers
Ukraine	38,299	21,216	10,441	5,169	1,473
Bulgaria	6,651	5,649	2.7		1000
Georgia	78		78		
Romania	7,196	3,144	4,052		
Russia	4,418		53	4,200	165
Turkey	760	7.3	753		
Total	57,404	30,106	15,379	9,369	2.638
Danube[a]	53,300				
High Sea[b]	136				
Total	110,840				

[a] Danube River is listed separately because it is a multi-national river and the imput from it is so high.

[b] Average for accidental spills on the high sea; only includes reported spills. Unreported spills could be very high and significant.